CULTURES OF UREDINEAE IN 1910

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The present article is the eleventh of a series of reports[1] by the writer upon the culture of plant rusts, beginning in 1899. Almost uniform progress has been made during the twelve years in the prime purpose of the work, that of experimentally connecting the sporophytic and gametophytic phases of heteroecious rusts, as well as the study of autoecious species and in some cases the detection of races. The work of the year is representative in these several respects. It was under the charge of Miss Irma A. Uhde, a senior student in general science in the University of Iowa, who was recommended by Professor Thomas H. Macbride. Miss Uhde conducted the work with fine insight and untiring patience, securing a notably large number of successful infections. Some of the sowings, particularly those of the cedar rusts were made and the records kept by Dr. F. D. Kern. All the work was done under the auspices of the Indiana Experiment Station, and financed from the Adams fund.

There are some very common American rusts that collectors of culture material are likely to send in considerable abundance every year, such as *Puccinia Caricis, P. Peckii, P. angustata* and the *Aster-Solidago-Erigeron* group among the sedge rusts, and *P. poculiformis, P. pustulata, P. Andropogonis, P. Impatientis* and *P. fraxinata* among the grass rusts. These are usually sown, although the life cycle is known, and when time and opportunity permit some tests are made regarding their less known aecial hosts and the possibility of races. While these and similar species take time that could usually be put upon less known forms to better advantage, there is another set of common rusts often sent by collectors, whose life cycle is not known, such as *Puccinia emaculata, P. Ellisiana, P. vexans,* and the form on *Carex Penn-*

[1] See Bot. Gaz. **29**: 268–276; **35**: 10–23; Jour. Myc. **8**: 51–56; **10**: 8–21; **11**: 50–67; **12**: 11–27; **13**: 189–205; **14**: 7–26; Mycol. **1**: 225–256; and **2**: 213–240.

sylvanica, which consume time with no more profit. They have been repeatedly sown, but for want of careful field observations regarding proximity of aecia, little advance is made.

Those who assisted in the work with culture material, and often with valuable suggestions, are named with special gratitude, for to them is due in considerable degree whatever of value has come from the year's labors. Mr. E. Bethel, Denver, Colo., sent 123 collections, by far the largest number contributed by one person in any year since the work began. Messrs. W. P. Fraser, Pictou, Nova Scotia, J. F. Brenckle, Kulm, N. D., and W. H. Long, Washington, D. C., sent between 30 and 40 collections each, while much smaller numbers were sent by Messrs. E. Bartholomew, Stockton, Kans., J. M. Bates, Red Cloud, Neb., H. S. Coe, Ames, Iowa, J. J. Davis, Racine, Wis., A. C. Dillman, Washington, D. C., H. S. Fawcett, Gainesville, Fla., A. O. Garrett, Salt Lake City, Utah, R. A. Harper, Madison, Wis., E. W. D. Holway, Minneapolis, Minn., Haven Metcalf, Washington, D. C., A. J. Norman, College Park, Md., E. W. Olive, Brookings, S. D., J. B. Pollock, Ann Arbor, Mich., Donald Reddick, R. E. Stone, and H. H. Whetzel, all three of Ithaca, N. Y., Guy West Wilson, Fayette, Iowa, and by Misses Louise Falk, Boulder, Colo., and Miriam Turner, Isle au Haut, Me. Many living plants were received from a number of botanists to whom requests had been sent for suitable specimens on which to make sowings of particular rusts. To all these and to others who assisted in the year's investigations the writer extends his heartiest thanks.

During the present season 294 collections of material with resting spores and 25 collections with active spores were employed, from which 987 drop cultures were made to test the germinating condition of the spores. Out of the 294 collections with resting spores 134 failed to germinate, leaving 160 collections available for experimental tests, this being a far larger number than in any previous year. Altogether about 400 sowings were made, using a great variety of hosts growing in pots in the greenhouse, and 75 infections obtained. The most important conclusions derived from a study of the results are given in the following paragraphs.

NEGATIVE RESULTS.—A number of collections giving good ger-

mination of the spores were sown on plants in the hope of discovering the alternate host but without securing infection. The following are recorded to serve for reference in future studies.

1. PUCCINIA on *Carex Pennsylvanica* L., collected at Kulm, N. D., by Dr. J. F. Brenckle, was sown on *Laciniaria punctata* (on 4 different dates), *L. spicata, Dirca palustris* (2 dates), and *Meriolix serrulata* (2 dates), with no infection. In preceding years this rust was sown on forty other species of hosts without infection.[2]

2. PUCCINIA on *Carex tenella* Schk., collected at Pictou, Nova Scotia, by Professor W. P. Fraser, was sown on *Phryma leptostachya* (on 2 different dates), with no infection. In 1909 a similar collection was sown on six other species of hosts with no results.[3]

3. PUCCINIA on *Carex stellulata* Good., collected by the writer at Isle au Haut, Me., was sown on *Aster Drummondii, Solidago canadensis,* and *Ribes Cynosbati,* with no infection.

4. PUCCINIA on *Carex trisperma* Dewey, collected at Pictou, Nova Scotia, by Professor W. P. Fraser, was sown on *Myrica cerifera, Apocynum cannabinum, Senecio Douglasii,* and *Solidago caesia,* with no infection.

5. PUCCINIA on *Carex arctata* Boott, collected at Pictou, Nova Scotia, by Professor W. P. Fraser, was sown on *Lysimachia terrestris, L. quadrifolia, Chelone glabra* (on 2 different dates), *Rudbeckia laciniata,* and *R. triloba,* with no infection.

6. PUCCINIA PERMINUTA Arth., on *Agrostis hyemalis* (Walt.) B. S. P., collected by the writer at Isle au Haut, Me., was sown on *Orchis spectabilis* and *Actaea alba,* with no infection. Another collection on *A. perennans* (Walt.) Tuckerm., collected at Pictou, Nova Scotia, by Professor W. P. Fraser, was sown on *Aquilegia canadensis, Thalictrum dioicum, Caulophyllum thalictroides, Anemonella thalictroides,* and *Isopyrum biternatum,* with no infection.

7. PUCCINIA ELLISIANA Thüm., on *Andropogon scoparius* Michx., collected by Dr. J. F. Brenckle, at Kulm, N. D., was

[2] See Jour. Myc. 10: 10. 1904; 11: 51. 1905; 12: 12. 1906; 13: 191. 1907; 14: 9. 1908; and Mycol. 1: 229. 1909.

[3] See Mycol. 1: 218. 1910.

sown on *Boehmeria cylindrica, Uvularia grandiflora, Myrica cerifera, Lysimachia quadrifolia, Thalictrum polygamum,* and *Laciniaria spicata,* with no infection. Similar material from Colorado, Nebraska, Delaware and North Carolina was sown in previous seasons on thirty five other species of hosts.[4]

8. PUCCINIA SCHEDONNARDI K. & S., on *Schedonnardus paniculatus* (Nutt.) Trel., collected by Mr. E. Bethel, at Westminster, Colo., was sown on *Delphinium formosum, Xanthoxylum americanum, Symphoricarpos pauciflorus, Hydrophyllum virginicum, H. capitatum, Onosmodium occidentale, Petalostemon purpureus, Amorpha nana, Boltonia asteroides, Grindelia squarrosa, Rudbeckia triloba, Laciniaria punctata, Solidago rigida,* and *Arnica* sp., with no infection. This collection possessed clean and well developed sori, and gave strong germination. Similar material in former years was sown on fifteen other species of hosts.[5]

9. PUCCINIA VIRGATA Ellis & Ev., on *Chrysopogon avenaceus* (Michx.) Benth., collected by Mr. W. H. Long at El Reno, Okla., was sown on *Dirca palustris, Xanthoxylum americanum, Boehmeria cylindrica, Apios Apios, Petalostemon purpureus,* and *Mimulus ringens,* with no infection. Similar material from Nebraska and North Carolina was sown in previous years on nine other species of hosts.[6]

10. PUCCINIA TOSTA Arth., on *Sporobolus asperifolius* Nees & Meyen, collected by Dr. J. F. Brenckle at Kulm, N. D., was sown on *Lepargyraea canadensis, Dirca palustris, Symphoricarpos racemosus, Apocynum cannabinum, Delphinium formosum, Polemonium reptans, Laciniaria punctata, Aster paniculatus,* and *Arnica* sp., with no infection.

Another collection on same host, made by Mr. E. Bethel at Denver, Colo., was sown on *Symphoricarpos racemosus, Lepargyraea canadensis, Phacelia heterophylla, Hydrophyllum virginicum, Lithospermum canescens, Amorpha fruticosa, Arabis Holboellii,* and *Sidalcea oregana,* with no infection. Similar material was sown in previous years on ten other species of hosts.[7]

[4] See Jour. Myc. **14**: 10. 1908; Mycol. **1**: 231. 1909; **2**: 220. 1910.

[5] See Bot. Gaz. **35**: 11. 1903; Jour. Myc. **13**: 192. 1907; **14**: 11. 1908; and Mycol. **1**: 231. 1909.

[6] See Jour. Myc. **14**: 10. 1908; and Mycol. **2**: 219. 1910.

[7] See Jour. Myc. **10**: 10. 1904; and **12**: 12. 1906.

11. PUCCINIA on *Phalaris arundinacea* L., collected by Dr. E. W. Olive, at Brookings, S. D., was sown on *Polygonatum commutatum, Vagnera stellata, Convallaria majalis, Uvularia grandiflora,* and *Trillium cernuum,* with no infection.

12. PUCCINIA DISTICHLIDIS E. & E., on *Spartina* sp., collected at Kulm, N. D., by Dr. J. F. Brenckle, was sown on *Lithospermum canescens* (on 2 different dates), *Onosmodium hispidissimum, Lepargyraea canadensis* (2 dates), *Elaeagnus angustifolia, Dirca palustris, Fraxinus lanceolata, Symphoricarpos racemosus, Aesculus glabra, Apocynum cannabinum, Hydrophyllum capitatum, Macrocalyx Nyctelea, Isopyrum biternatum, Amorpha nana, Cassia chamaecrista, Petalostemon purpureus, Physalis* sp., *Ambrosia trifida,* and *Carduus Flodmanii,* with no infection. A year ago the same rust was sown on three other hosts without results.[8]

13. PUCCINIA ANTHOXANTHI Fckl., on *Anthoxanthum odoratum* L., collected by Professor W. P. Fraser, at Pictou, Nova Scotia, was sown on *Berberis vulgaris, Myrica cerifera, Apocynum cannabinum, Tissa canadensis, Senecio lugens,* and *Rudbeckia triloba,* with no infection.

14. PUCCINIA on *Trisetum majus* (Vasey) Rydb. having covered telia and coronate teliospores, simulating *P. Rhamni,* collected in the foothills of Colorado, by Mr. E. Bethel, was sown on *Rhamnus alnifolia* from one collection, and on *Rhamnus cathartica* from another. A similar collection from Golden, Colo., with same data, was sown on the two sets of *Rhamnus,* while another collection from Boulder, Colo., was sown on *Mahonia Aquifolium* and *Arabis Holboellii.* In each instance there was no infection.

15. PUCCINIA MONTANENSIS Ellis, on *Elymus canadensis* L. collected by Mr. E. Bethel, at Colorado Springs, Colo., was sown on *Clematis virginiana* (on 2 different dates), *Viorna Douglasii* (2 dates), *Impatiens aurea, Delphinium scaposum, Viola septentrionalis, Arabis Holboellii, Amorpha nana, Senecio Douglasii,* and *Arnica* sp., with no infection. In 1907 what is thought to be the same rust was sown four times on *Delphinium tricorne* without result.[9]

[8] See Mycol. 2: 219. 1910.

[9] See Jour. Myc. 14: 11. 1908.

16. UROMYCES ELEOCHARIDIS Arth., on *Eleocharis palustris* (L.) R. & S., collected by Dr. E. W. Olive, at Brookings, S. D., was sown on *Laciniaria spicata, L. scariosa, Eupatorium serotinum, Polygala Senega, Hydrophyllum virginicum, Amorpha fruticosa, Symphoricarpos racemosus, Lepargyraea canadensis,* and *Dirca palustris,* with no infection. In 1906 the same rust was sown on five other species of hosts without results.[10]

17. UROMYCES SPARTINAE Farl., on *Spartina Michauxiana* A. S. Hitch. (usually listed as *S. cynosuroides*), collected by Professor W. P. Fraser, at Pictou, Nova Scotia, was sown on *Steironema ciliatum* (on 2 different dates), *Polemonium reptans, Phlox divaricata,* and *Tissa canadensis,* with no infection.

Another collection from the same collector and place, but on *S. patens* (Ait.) Muhl., was sown on *Steironema ciliatum* (2 dates), *Polemonium reptans,* and *Lysimachia terrestris,* with no infection.

It is evident from the present repeated inability to infect *Steironema* with *Spartina* rust from the salt marshes of the sea coast, supposedly the same species as in the interior,[11] that the status of this rust, or group of rusts, is not yet fully known. Either we are dealing with more species than heretofore recognized, or there are biological races yet undetermined.

18. UROMYCES PECKIANUS Farl., on *Distichlis spicata* (L.) Greene, collected by Professor W. P. Fraser, at Pictou, Nova Scotia, was sown on *Tissa canadensis* (on 2 different dates), *Mimulus ringens,* and *Rudbeckia laciniata,* with no infection.

19. UROMYCES GRAMINICOLA Burr., on *Panicum virgatum* L., collected by Mr. W. H. Long, at El Reno, Okla., was sown on *Dirca palustris, Apios tuberosa,* and *Boltonia asteroides,* with no infection. Another collection on the same host sent by Mr. E. Bartholomew from Stockton, Kans., was sown on *Apios tuberosa, Petalostemon purpureus, Cassia chamaecrista, Aesculus glabra, Apocynum cannabinum,* and *Laciniaria spicata,* with no infection.

The same rust has been sown on eleven other species of hosts in previous years.[12]

[10] See Jour. Myc. 13: 193. 1907.

[11] For a statement regarding *Uromyces* on *Spartina* see Mycol. 2: 221. 1910.

[12] See Jour. Myc. 12: 13. 1906; Mycol. 1: 232. 1909; 2: 220. 1910.

20. UROMYCES SPOROBOLI E. & E., on *Sporobolus neglectus* Nash, collected by Dr. E. W. Olive, at Brookings, S. D., was sown on *Lepargyraea canadensis, Elaeagnus angustifolia, Amorpha nana, Erigeron annuus* (on two different dates), and *Arnica* sp., with no infection.[13]

21. AECIDIUM on *Euphorbia commutata* Engelm. was obtained in the vicinity of Lafayette, Ind., by Messrs. F. D. Kern and T. Billings. The living plants were placed in pots and continued to flourish. They bore aecia in all stages of maturity. These plants were adjusted in a moist chamber over the following hosts, so that aeciospores fell spontaneously upon the young leaves: *Astragalus canadensis, Pisum sativum, Lathyrus palustris, Medicago sativa,* and *Trifolium pratense.* No infection was obtained.

SUCCESSFUL CULTURES SUPPLEMENTING PREVIOUS WORK.—The facts derived by growing the following species of rusts supplement those obtained from previous cultures in this series or from cultures recorded by other American or European investigators.

1. PUCCINIA GROSSULARIAE (Schum.) Lagerh., on *Carex tenuis* Rudge, collected at Pictou, Nova Scotia, by Professor W. P. Fraser, was sown April 7 on *Erigeron annuus, Solidago canadensis, Aster paniculatus* and *Ribes Cynosbati,* with infection only on the last,[14] showing pycnia April 16, and aecia April 25. Similar material obtained by the writer at Isle au Haute, Me., was sown on the same hosts, but omitting *Erigeron,* and with similar results.

A collection on *Carex pallescens* L., made by Professor W. P. Fraser at Pictou, Nova Scotia, the previous fall, was sown April 8 on *Erigeron annuus, Solidago canadensis, Aster paniculatus* and *Ribes Cynosbati,* with infection only on the last, showing abundant pycnia April 16, and aecia April 22. A similar collection, made by Prof. Fraser in the spring, was sown April 18, without infection, on *Lysimachia terrestris, Lactuca scariola, Rudbeckia laciniata, Polygala Senega* and *Apocynum cannabinum.* Two days earlier it was sown on *Ribes Cynosbati,* resulting in good infection, showing pycnia April 27, and aecia May 3.

[13] See Bot. Gaz. 35: 11. 1903.

[14] For similar negative results see Mycol. 2: 218. 1910.

The *Carex* rusts having aecia on *Ribes* are yet imperfectly known. My own culture work began in 1901, and owing to the remarkably pale aecia produced, the form in hand at the time was named *Puccinia albiperidia.* Since then many cultures have been made, and the status of the species has received considerable attention, but not until recently has any well marked morphological characters been discovered. Present studies indicate that *P. albiperidia* is a species worthy of being maintained. Beside the more or less pale aecia it possesses one basal pore in the urediniospore.

It is curious to note that the only other species of monocotyledonous rust known with a single basal pore in the urediniospore, *Uromyces uniporulus* Kern, is also on *Carex.* When published it had only been found in Connecticut on *C. tenuis.* Since then it has been detected in Wisconsin on *C. gracillima.* These are also the hosts of *P. albiperidia,* together with *C. pallescens* and *C. pubescens.* Comparing the spores, it appears that the urediniospores of the *Puccinia* and of the *Uromyces* not only agree in the pore characters, but also as to form, size and color, *i. e.,* in all morphological characters. The teliospores are also alike except in number of cells, and in the consequent length. If the sori of the *Puccinia* often contained many one-celled teliospores, and the sori of the *Uromyces* often had a few two-celled spores, *U. uniporulus* might be considered a mere mesoporic form of *P. albiperidia.* But such does not appear to be the case. However, while in the present state of uredinological taxonomy the two forms are to be maintained as distinct species belonging to different genera, yet *U. uniporulus* is doubtless only a morphological race of *P. albiperidia.* Cultures of *P. albiperidia* were made in 1901, 1903 and 1904.[15] No cultures have yet been made of *U. uniporulus,* but it probably has aecia on *Ribes.*

The far more common and widely distributed species, for which I am making the name *Puccinia Grossulariae* serve, has more deeply colored aecia and three equatorial pores in the urediniospore. I am inclined to think that this is the common gooseberry-*Carex* rust of this country and Europe, but I am not able at present to define its limits, neither can I say whether the

[15] See Jour. Myc. 8: 53. 1902; 10: 11. 1904; and in part 11: 58. 1905.

currant-*Carex* rusts belong here or not. My previous cultures[16] of this form have been reported under the name *P. albiperidia,* and confused with that species.

2. PUCCINIA PECKII (DeT.) Kellerm., on *Carex lanuginosa* Michx., collected at Kulm, N. D., by Dr. J. F. Brenckle, was sown April 7 on *Onagra biennis* and *Meriolix serrulata,* with no infection on the latter, but with abundant pycnia on the former April 16, and aecia April 25.

Another collection on *Carex trichocarpa* Muhl., made at Carmel, Ind., by Messrs. F. D. Kern and A. G. Johnson, was sown April 13 on plants of the same two species of hosts with similar results. There was no infection of the *Meriolix,* but abundance of pycnia showed on the *Onagra* April 23, and aecia May 5. A duplicate sowing was made May 11, which gave a few pycnia on the *Meriolix,* but no aecia developed, while on the *Onagra* abundance of pycnia appeared May 19, and aecia May 27.[17]

In previous years this species of rust has been grown on *Onagra biennis* and *Gaura biennis,* the two hosts being very similar in vegetative structure. Aecia have been gathered in the field on a number of related hosts with less similarity in vegetative structure, such as *Meriolix,* but heretofore no cultural studies have been made. The present attempt may be interpreted as indicating that certain outlying hosts are infected only under exceptionally favorable circumstances, or that there exist more or less well marked races.

3. PUCCINIA CARICIS-SOLIDAGINIS Arth., on *Carex scoparia* Schk., collected by the writer at Isle au Haut, Me., was sown April 20, on *Euthamia graminifolia* (*Solidago lanceolata*) and *Solidago rugosa,* with infection only on the former, abundance of pycnia showing April 30, and aecia May 9. Another sowing was made June 10 on the same two hosts, and on *S. canadensis, S. nemoralis, Doellingeria umbellata* and *Aster paniculatus,* with

[16] See Jour. Myc. 11: 58. 1905 (in part); 12: 14. 1906; 13: 196. 1907; and 14: 13. 1908.

[17] For previous cultures see Bot. Gaz. 35: 13. 1903; Jour. Myc. 8: 52. 1902; 11: 58. 1905; 12: 15. 1906; 13: 195. 1907; Mycol. 1: 233. 1909; and 2: 222. 1910.

infection only on the *Euthamia,* showing pycnia June 18, and aecia July 5.[18]

All the hosts used in the trial are common in the vicinity where the telial material was obtained and bear aecia. It is highly probable that the aecial forms occurring on *Solidago, Aster, Erigeron, Euthamia,* and possibly *Doellingeria,* belong to one species made up of fairly well defined races. The form on *Euthamia* appears from present data to constitute a race distinct from that on *Solidago,* but is here included under the same name.

4. PUCCINIA CARICIS-ASTERIS Arth., on *Carex festiva* Dewey collected by Mr. E. Bethel, at Tolland, Colo., 9,000 feet altitude, was sown April 13, on *Aster adscendens* Lindl. (*A. Tweedyi* Rydb.), and the day following on *Onagra biennis,* with no infection on the latter and abundant infection on the former, giving pycnia April 27, and aecia May 2. Another collection with same data was sown on *Aster adscendens* April 9, and again on May 4, only the latter being effective, giving pycnia in abundance May 14, and aecia May 21.[19]

5. PUCCINIA OPIZII Bubák, on *Carex siccata* Dewey, collected by Dr. J. F. Brenckle, at Kulm, N. D., was sown as follows:

April 9, *Lactuca canadensis:* pycnia April 16, aecia April 25.
April 9, *Lactuca sativa:* pycnia April 25, aecia May 2.
April 19, *Lactuca canadensis:* pycnia April 30, aecia none.
April 19, *Lactuca sativa:* pycnia May 6, aecia none.

In the sowings on both dates the infection developed more slowly and less abundantly on the garden lettuce (*L. sativa*), than on the wild form. In both of the late sowings the aecia failed to appear, because the leaves matured too soon and died.[20]

6. PUCCINIA UNIVERSALIS Arth., on *Carex stenophylla* Wahl., collected by Mr. E. Bethel, at Boulder, Colo., was sown April 19, on *Artemisia dracunculoides,* giving abundance of pycnia April 29, and aecia May 3.[21]

[18] For previous cultures see Bot. Gaz. 35: 21. 1903; Jour. Myc. 12: 15. 1906; and Mycol. 1: 233. 1909.

[19] For previous cultures see Bot. Gaz. 35: 15. 1903; Jour. Myc. 8: 54. 1902; 14: 13. 1908; and Mycol. 2: 224. 1910.

[20] For previous culture from an undetermined *Carex* see Jour. Myc. 13: 194. 1907.

[21] For previous cultures see Jour. Myc. 14: 21. 1908; and Mycol. 2: 224. 1910.

7. PUCCINIA CARICIS (Schum.) Schröt., on *Carex aristata* R. Br., collected by Dr. J. F. Brenckle, at Kulm, N. D., was sown April 7, on *Urtica gracilis* and *Boehmeria cylindrica,* with infection only on the former, giving pycnia April 13, and aecia April 19.

Another collection on *Carex stricta* Lam., made in the vicinity of Lafayette, Ind., by Mr. A. G. Johnson, was sown April 13, on the same two hosts, producing infection only on *Urtica gracilis,* giving pycnia April 22, and aecia April 27. Similar results were obtained in previous years.[22]

8. PUCCINIA ANGUSTATA Peck, on *Scirpus atrovirens* Muhl., collected by Messrs. F. D. Kern and A. G. Johnson, at Carmel, Ind., was sown April 7, on *Lycopus americanus,* giving pycnia April 16, and aecia April 22. Another similar collection made by Mr. A. G. Johnson near Lafayette, Ind., was sown on same host April 13, giving pycnia April 25, and aecia May 1.[23]

9. PUCCINIA ANDROPOGONIS Schw., on *Andropogon virginicus* L., collected at Clarendon, W. Va., by Mr. W. H. Long, was sown May 13, on *Pentstemon hirsutus,* giving pycnia May 23, and aecia June 7. Another collection on *A. scoparius* Michx., made at Boulder, Colo., by Mr. E. Bethel, was sown May 12 on *Comandra umbellata* and *Pentstemon alpinus,* with infection only on the latter, and not abundant, pycnia and aecia not being observed until May 31.[24]

10. PUCCINIA PUSTULATA (Curt.) Arth., on *Andropogon furcatus* Muhl., collected at Plainview, Colo., by Mr. E. Bethel, was sown April 13, on *Comandra umbellata* and *Pentstemon barbatus,* giving rise to infection only on the former, showing pycnia April 27, and aecia May 9. Another collection by Mr. Bethel from Colorado on *Andropogon* sp., was sown May 12 on *Comandra umbellata* and *Pentstemon alpinus,* with infection only on the former, giving pycnia in abundance May 20, and aecia May 31.[25]

[22] For previous cultures see Bot. Gaz. **29**: 270. 1900; **35**: 16. 1903; Jour. Myc. **8**: 52. 1902; **12**: 15. 1906; **14**: 14. 1908; and Mycol. **2**: 223. 1910.

[23] For previous cultures see Bot. Gaz. **29**: 273. 1900; Jour. Myc. **8**: 53. 1902; **11**: 58. 1905; **13**: 196. 1907; **14**: 14. 1908; and Mycol. **1**: 234. 1909.

[24] For previous cultures see Bot. Gaz. **29**: 272. 1900; Jour. Myc. **10**: 11. 1904; and **13**: 197. 1907.

[25] For previous cultures see Jour. Myc. **10**: 17. 1904; and **12**: 16. 1906.

11. PUCCINIA AMPHIGENA Diet., on *Calamovilfa longifolia* (Hook.) Hack., collected by Dr. J. F. Brenckle, at Kulm, N. D., was sown April 25, on *Smilax hispida,* giving rise to pycnia in abundance May 2, and aecia May 14.[26]

12. PUCCINIA MUHLENBERGIAE Arth. & Holw., on *Muhlenbergia racemosa* (Michx.) B. S. P., collected by Dr. J. F. Brenckle, at Kulm, N. D., was sown May 6, on *Hibiscus militaris, Napaea dioica* and *Callirrhoe involucrata,* with infection only on the last, giving abundance of pycnia that were first seen May 23, and aecia May 27.[27] Another collection of the rust on *M. gracilis,* sent by Mr. E. Bethel, from the foothills of Colorado, was sown on the same three hosts, with no infection. Still a third collection, on *M. racemosa,* sent by Mr. E. Bartholomew from Stockton, Kans., was sown May 11, on *Hibiscus militaris* and *Althaea rosea,* without infection.

13. PUCCINIA RHAMNI (Pers.) Wettst., on *Calamagrostis canadensis* (Michx.) Beauv., collected by Professor W. P. Fraser, at Pictou, Nova Scotia, was sown May 26, on *Rhamnus alnifolia,* giving a strong infection, pycnia showing June 6, and aecia June 10. The only previous cultures in the series were made with aeciospores.[28]

14. PUCCINIA POCULIFORMIS (Jacq.) Wettst., on *Agropyron tenerum* Vasey, collected by Mr. E. Bethel, at Boulder, Colo., was sown April 25, on *Berberis vulgaris,* giving pycnia May 2, and aecia May 14. Another collection by Mr. Bethel, on *Sitanion longifolium* J. G. Sm., made at Eldorado Springs, Colo., was sown May 3, on *Berberis vulgaris,* giving pycnia May 14, and aecia May 26. Still another collection on *Agrostis alba* L., made by the writer at Isle au Haut, Me., was sown April 19, on *Berberis vulgaris,* giving pycnia April 29, and aecia May 9.[29]

15. PUCCINIA SUBNITENS Diet., on *Distichlis spicata* (L.) Greene, collected by Dr. J. F. Brenckle, at Kulm, N. D., was sown May 4, on *Chenopodium album, Monolepis Nuttalliana,* and *Cory-*

[26] For previous cultures see Bot. Gaz. 35: 20. 1903; Jour. Myc. 10: 11. 1904; 12: 16. 1906; 14: 15. 1908; and Mycol. 2: 225. 1910.

[27] For previous cultures see Mycol. 1: 251. 1909; and 2: 226. 1910.

[28] See Jour. Myc. 11: 58. 1905.

[29] For previous cultures see Jour. Myc. 8: 53. 1902; 11: 57. 1905; 12: 17. 1906; 13: 198. 1907; 14: 16. 1908; and Mycol. 2: 227. 1910.

dalis aurea, with infection only on the first, giving numerous pycnia May 16, and aecia May 21. Another sowing was made May 25, on *Chenopodium album, Monolepis Nuttalliana, Corydalis sempervirens,* and *Tissa canadensis,* and again infection was only obtained on the first, giving pycnia June 5, and aecia June 16. These attempts add nothing materially to previous knowledge.[30]

16. PUCCINIA JAMESIANA (Peck) Arth., on *Atheropogon curtipendulus* (Michx.) Fourn., collected by Mr. W. H. Long, at Amarillo, Texas, was sown April 19, on *Asclepias syriaca,* giving pycnia May 3, and aecia May 9. Previous cultures were also made with Texan material sent by Mr. Long.[31]

17. PUCCINIA SEYMOURIANA Arth., on *Spartina Michauxiana A. S. Hitch,* collected by Mr. W. H. Long, at El Reno, Okla., was sown June 3, on *Cephalanthus occidentalis,* giving numerous pycnia June 11, and aecia June 24.[32]

18. PUCCINIA STIPAE Arth., on *Stipa spartea* Trin., collected by Dr. E. W. Olive, at Brookings, S. D., was sown May 10, on *Aster ericoides* and *A. Novae-Angliae,* giving pycnia in both cases May 19, without developing aecia on *A. ericoides,* but giving aecia on *A. Novae-Angliae* May 26.

Another collection made by the writer on the same host, at Spirit Lake, Iowa, was sown April 28, on *Aster multiflorus,* giving pycnia May 6, and aecia May 17. A second sowing was made May 6, on *Aster Novae-Angliae,* with pycnia May 16, and aecia May 23; on *A. multiflorus,* with pycnia May 17, and aecia May 23; on *Solidago canadensis,* with pycnia May 24, and aecia June 6; and on *Grindelia squarrosa,* without infection.

Another collection made by Mr. E. Bethel, at Golden, Colo., on *Stipa* sp., was sown April 22, on *Aster Novae-Angliae,* with pycnia May 2, and aecia May 16, on *Grindelia squarrosa,* with pycnia May 2, and aecia May 16, and on the following hosts without infection: *Aster ericoides, A. multiflorus, Solidago cana-*

[30] For previous cultures see Bot. Gaz. 35: 19. 1903; Jour. Myc. 11: 54. 1905; 12: 16. 1906; 13: 197. 1907; 14: 15. 1908; Mycol. 1: 234. 1909; and 2: 225. 1910.

[31] For previous cultures see Bot. Gaz. 35: 18. 1903.

[32] For previous cultures see Jour. Myc. 12: 24. 1906; and Mycol. 1: 236. 1909.

densis, Arnica sp., *Boltonia asteroides, Laciniaria scariosa, Symphoricarpos racemosus,* and *Hydrophyllum virginicum.*

Still another collection of what appears to be the same species of rust was collected on *Koeleria cristata* (L.) Pers., by Miss Louise M. Falk, at Boulder Colo., and sown April 27, on *Senecio lugens, Grindelia squarrosa, Symphoricarpos racemosus, Hydrophyllum virginicum,* and *Arabis Holboellii,* with infection only on the first, which showed pycnia May 14, and aecia May 19.

The aecia on the several hosts, thus produced, correspond in structure, and are peculiar in having evanescent peridia, the spores being retained by the surrounding tissues of the hypertrophied leaf. The striking appearance of the aecial groups suggested one of the early synonyms: *Aecidium sclerothecioides* Ellis & Ev. These cultures, although still lacking in completeness, have enabled us to bring together a number of uncertain forms with a considerable degree of assurance, and to extend both aecial and telial hosts.

19. PUCCINIA ARGENTATA (Schultz) Wint. At my request Professor Guy West Wilson, of Fayette, Iowa, made a somewhat trying excursion to Decorah, Iowa, and with the aid of directions supplied by Professor E. W. D. Holway, who resided there for many years, obtained living plants of *Adoxa Moschatellina* L., bearing aecia, which were potted and thrived. Two sowings were made April 18, by suspending the plants of *Adoxa* bearing aecia over plants of *Impatiens aurea.* In both instances a great abundance of urediniospores began to appear May 2. Again on April 21, two more similar sowings were made on other plants of *Impatiens,* and an equal abundance of urediniospores appeared May 3. These were followed on all four plants by an unusual abundance of teliospores, the record being made June 6, although they first appeared somewhat earlier.

The aecia on *Adoxa,* which are of limited distribution in America, early attracted the writer's attention, and as early as 1883[33] a first attempt was made toward solving their life history. Since the cultures of Bubák[34] proved that the European form on *Adoxa* was the aecial stage of telia on *Impatiens,* I have attempted to

[33] Bot. Gaz. 10: 369. 1885.
[34] Centr. Bakt. 10^2: 574. 1903.

secure American material for cultures, and the ample success when finally obtained is most gratifying. The American and European collections of this interesting heteroecious rust appear alike, and the present cultures show them to be identical.

20. PUCCINIA ABSINTHII DC., on a densely canescent species of *Artemisia,* collected by Mr. E. Bethel, at Boulder, Colo., was sown April 20, on *A. dracunculoides,* giving pycnia May 2, and uredinia May 20, thus confirming the previous cultures of two years ago.[35]

21. UROMYCES PERIGYNIUS Halst., on *Carex intumescens* Rudge, collected by Professor W. P. Fraser, at Pictou, Nova Scotia, was sown April 21, on *Solidago nemoralis,* again April 26, on *S. canadensis,* on May 13, on both *S. nemoralis* and *S. canadensis,* and also on *Aster paniculatus,* and finally May 14, on *Tissa canadensis* and *Artemisia ludoviciana.* Quite unexpectedly the only sowing producing infection was on *Aster,* giving pycnia May 19, and aecia May 31, both abundantly developed.

Another collection apparently of the same rust, sent by Professor Fraser, on *Carex deflexa* Hornem., was sown May 28, on *Solidago rugosa, S. canadensis* and *Aster Drummondii,* with infection only on the first, giving abundance of pycnia June 4, and aecia June 16.

A collection on *Carex deflexa,* collected by the writer at Isle au Haut, Me., was sown May 13, on *Solidago rugosa, S. nemoralis,* and *Aster ericoides.* On *S. rugosa* numerous pycnia appeared May 20, and aecia May 31, but *S. nemoralis* remained free. The *Aster,* moreover, showed pycnia May 24, and aecia June 6, but they were not numerous and grew slowly. *Solidago rugosa* has been taken with aecia in the telial vicinity, but *Aster ericoides* does not grow there neither does any closely related species of *Aster.*

Considerable study has been given to the species of *Uromyces* on *Carex* since the initial and only culture[36] in 1903. Some of the conclusions may be briefly stated, without giving the steps by which they were reached. We are doubtless dealing with races, more or less well defined, parallel with the races of the *Puccinia*-group, which latter goes under several names, two being given

[35] See Mycol. 1: 243. 1909.

[36] See Jour. Myc. 10: 15. 1904.

above under nos. 3 and 4, and which have aecia on *Aster, Solidago, Euthamia, Erigeron,* and close relatives. As the aecia and uredinia of the two groups, one under the genus *Puccinia* and the other under *Uromyces,* are indistinguishable, and as the teliospores of the *Uromyces* agree with the one-celled spores of the *Puccinia,* and also with the two-celled spores in all characters except number of cells and consequent length, the former doubtless are morphological races of the latter. Relationship could be shown better by putting all of these forms under one specific name, and designating the several races by varietal names. But in the present state of taxonomy of the rusts it is more convenient to dispose of them under the two genera: *Puccinia* and *Uromyces.*

The collection on *Carex intumescens* used in the culture is in all respects identical with the type collection of *Uromyces perigynius,* which was also on *C. intumescens,* but in the latter the large green perigynia also bore sori as well as the leaves, which unusual but incidental fact suggested the name. The similarity of this species with the form having aecia on *Solidago* was pointed out in 1903,[37] but for precautionary reasons it was thought best at that time to give the latter a separate name, *U. Solidagini-Caricis* Arth. This name now becomes a synonym of the former, or may be used to indicate the biological race with aecia on *Solidago.* The type host of this form has been determined as *C. deflexa,* and not *C. varia* as originally stated.

It is further probable that the form on *Carex scoparia* bearing the name *U. caricina* Peck, which often shows larger spores, should be referred to *U. perigynius,* the last being the oldest name of the three. A collection of this on *C. scoparia* was sent by Professor Fraser, from Pictou, Nova Scotia, and sown on *Lysimachia terrestris,* without infection. Its possible relation to the *Aster-Solidago* group did not come to mind soon enough to put the matter to a test.

22. UROMYCES JUNCI (Desm.) Tul., on *Juncus balticus* Willd. collected at Kulm, N. Dak., by Dr. J. F. Brenckle was sown April 14 on *Carduus Flodmanii, Arnica* sp., *Grindelia squarrosa, Ambrosia trifida,* and *Sidalcea oregana,* with infection only upon the first, showing pycnia April 29, and aecia May 4. Another sowing

[37] L. c.

May 10 on *Carduus Flodmanii* produced pycnia May 19 and aecia June 5. Another collection from the same place but taken at a different date was sown May 19 on *Carduus Flodmanii,* showing pycnia May 28 and aecia June 5. Three other collections of what appears to be the same rust on the same host, also sent from Kulm, N. Dak., by Dr. Brenckle but collected at different times were sown on *Carduus Flodmanii* (various dates), and one of these was also sown upon eighteen other species of hosts, all with no infection. Still another collection on *J. balticus* from Granby, Colo., sent by Mr. E. Bethel was sown on *Carduus Flodmanii* without infection.

The results here given appear to support the suggestion made in the last report[38] that this species is composed of races. The failure to infect *Pulicaria* with American material, as there stated, seems to indicate that American and European forms represent different races. The failure to infect *Carduus* with some of the sowings was also doubtless due to the existence of races. Mr. Bethel has since suggested that his collection from Granby is probably connected with aecia on *Arnica,* and both Mr. Bethel and Dr. Brenckle are of the opinion that there is a form of this species with aecia on *Ambrosia psilostachya.*

23. UROMYCES ASTRAGALI Sacc., on *Aragallus Lamberti* (Pursh) Greene (*Oxytropis Lamberti* Pursh), collected by Mr. E. Bethel at Leyden, Colo., was sown on *Euphorbia Cyparissias,* without result.

A collection bearing uredinia (*Uredo Oxytropi* Peck) on *Aragallus Lamberti* (Pursh) Greene, sent by Mr. Bethel from Boulder, Colo., was sown September 30, on *Astragalus carolinianus,* giving rise to uredinia that were first noticed October 22.

A collection bearing uredinia on *Astragalus sulphurescens* Rydb., sent by Mr. E. Bethel, from Boulder, Colo., was sown Sept. 30, on *A. carolinianus,* and on October 22, uredinia were observed, although they may have appeared somewhat earlier.

We have yet made no appreciable headway toward ascertaining the aecial condition of this rust, but the present cultures do show that the *Oxytropis* rust, which has usually been kept distinct, is

[38] Mycologia 2: 220. 1910.

identical with the widespread *Astragalus* rust. The species is one that does not readily produce teliospores.

24. UROMYCES MEDICAGINIS Pass., on *Medicago sativa* L., was sent by Mr. H. S. Coe, from Ames, Iowa. Urediniospores were sown September 26, on *Medicago sativa* in the greenhouse, and uredinia began to appear October 8. On November 14, uredinia from this culture were sown on *Medicago sativa, Trifolium pratense, T. medium,* and *T. repens,* giving uredinia on the first December 3, but with no infection of the *Trifolium* plants.

The aecia of *Medicago* rusts are not definitely known. In Europe a form usually assumed to be the same occurs on *Trifolium pratense,* and this was made by Schröter to infect *Euphorbia Cyparissias.* This form has not been detected in America. The present culture seems to show that the *Medicago* rust will not pass over to *Trifolium,* at least by means of urediniospores.

25. GYMNOSPORANGIUM JUNIPERI-VIRGINIANAE Schw., on *Juniperus virginiana* L., collected by Dr. F. D. Kern in the vicinity of Lafayette, Ind., was sown April 7, on *Malus Malus,* giving numerous pycnia April 19, but the leaves matured before aecia were formed.[39]

26. GYMNOSPORANGIUM CLAVIPES C. & P., on *Juniperus sibirica* Burgsd., was sent by Dr. J. J. Davis, from Wind Lake, Wis., and sown May 3, on *Amelanchier erecta* and *Crataegus tomentosa,* giving numerous pycnia on both hosts May 16, and equally numerous aecia June 6, for the first host and June 11, for the second.

Aecia from this culture on *Amelanchier erecta* were used to sow June 7, on a small plant of *Juniperus sibirica,* and many finely developed telia appeared in May 1911, the exact date not recorded.[40]

These cultures are interesting in showing that the telia mature in the spring following infection, and do not require an additional year as some other species of *Gymnosporangium* do.

27. GYMNOSPORANGIUM CLAVARIAEFORME (Jacq.) DC., on *Juni-*

[39] For previous cultures see Jour. Myc. 12: 13. 1906; 13: 200. 1907; 14: 17. 1908; and Mycol. 1: 238. 1909.

[40] For previous cultures see Jour. Myc. 14: 18. 1908; Mycol. 1: 239. 1909; and 2: 229. 1910.

perus sibirica Burgsd., was sent by Mr. E. Bethel, from Boulder, Colo., and sown April 7, on the young fruit of *Pyrus communis,* which fell off before time for infection to show, and also on the leaves of *Amelanchier erecta* and *Crataegus punctata.* On the *Crataegus* a few pycnia showed April 15, but no aecia developed. On the *Amelanchier* numerous pycnia appeared April 13, and many aecia April 25.[41]

28. GYMNOSPORANGIUM NIDUS-AVIS Thaxt., on *Juniperus virginiana* L., was sent from Washington, D. C., by Dr. Haven Metcalf, and sown April 16, on leaves of *Cydonia vulgaris,* giving a few pycnia May 2, and also on the young fruit of *Amelanchier vulgaris,* giving a few pycnia first noticed May 24. In both instances no further development occurred.[42]

29. GYMNOSPORANGIUM CORNUTUM (Pers.) Arth., on *Juniperus sibirica* Burgsd., sent from Palmer Lake, Colo., by Mr. E. Bethel, was sown May 18 on *Sorbus americana, Aronia arbutifolia,* and *Amelanchier erecta.* Infection was secured only on the *Sorbus,* the pycnia being produced in abundance but tardily, and the date was not taken. The plant did not thrive, and no aecia matured, although on August 16 they were showing.[43]

30. GYMNOSPORANGIUM DAVISII Kern, on *Juniperus sibirica* Burgsd., sent by Dr. J. J. Davis from Wind Lake, Wis., was sown May 3, on *Aronia arbutifolia, A. nigra, Sorbus americana, Amelanchier erecta* and *Crataegus tomentosa,* without results. Another sowing was made May 12, on the two species of *Aronia,* which resulted in a few pycnia on *A. nigra,* showing May 27. Still another sowing on *A. arbutifolia* was made May 18, and gave a few pycnia May 25. In neither instance did aecia develop.[44] It is probable that the conditions under which the cultures are made in the greenhouse are not favorable for this rust.

31. GYMNOSPORANGIUM BETHELI Kern, on *Juniperus scopulorum* Sarg., sent by Mr. E. Bethel from Boulder, Colo., was sown

[41] For previous cultures see Jour. Myc. 14: 18. 1908; and Mycol. 1: 239. 1909.

[42] For previous cultures see Jour. Myc. 14: 19. 1908; and Mycol. 2: 230. 1910.

[43] For previous cultures see Mycol. 1: 240. 1909; and 2: 230. 1910.

[44] For previous cultures see Mycol. 1: 241. 1909, where an error was made in assuming that this species occurs in Europe; see also Mycol. 2: 216. 1910.

April 16, on *Crataegus cerronis* A. Nels., giving rise to numerous pycnia April 25, and equally numerous aecia May 23.[45]

32. GYMNOSPORANGIUM NELSONI Arth., on *Juniperus virginiana* L., sent by Professor R. A. Harper from Merrimack, Wis., was sown May 2, on *Amelanchier erecta, Cydonia vulgaris* and *Malus coronaria.* Infection was only on *Amelanchier,* showing an abundance of pycnia May 11, and equally numerous aecia June 8.[46] This rust is not often seen east of the Rocky Mountains. The witches' brooms which are produced have a general resemblance to those of *G. nidus-avis,* and it may sometimes be confused with that species.

33. CRONARTIUM QUERCUS (Brond.) Schröt. Aecia (*Peridermium Cerebrum* Peck) on *Pinus virginiana* Mill., were sent by Mr. W. H. Long, from the vicinity of Washington, D. C., and sown April 28, on *Quercus rubra.* The first appearance of uredinia was not recorded, but on May 20, a few uredinia and many telia were observed.[47]

34. MELAMPSOROPSIS ABIETINA (A. & S.) Arth., on *Ledum groenlandicum* Oeder, sent by Professor W. P. Fraser from Pictou, Nova Scotia, was sown June 15 on *Picea Mariana* (Mill.) B. S. P., giving numerous pycnia June 23, and aecia about August 12. This connection was first suggested by the field observations of Anton de Bary in the Alps, and by him proven by means of cultures in 1879.[48] A number of field observations by other mycologists were recorded, tending to fortify the result, but no other cultures were made until 1901, when Klebahn[49] verified the work of de Bary.

The probable connection of *Ledum* and *Picea rusts* in America was discussed by Professor W. G. Farlow in 1885,[50] based largely

[45] For previous cultures see Jour. Myc. 14: 23. 1908; Mycol. 1: 240. 1909; and 2: 230. 1910.

[46] For previous cultures see Jour. Myc. 13: 203. 1907; 14: 18. 1908; and Mycol. 1: 239. 1909. Studies published by Dr. F. D. Kern (Bull. N. Y. Bot. Gard. 7: 448. Oct. 1911) since this article went to press show that the form used in this culture, and also in the previous ones here referred to, has been erroneously referred to *G. Nelsoni,* it should be called *G. juvenescens* Kern.

[47] For previous cultures see Jour. Myc. 13: 194. 1907.

[48] Bot. Zeit. 37: 802. 1879.

[49] Zeitschr. Pflanzenkr. 12: 17. 1902.

[50] Proc. Amer. Acad. Sci. 20: 320. 1885.

upon his observations in the White Mountains of New Hampshire, but at that time too little study had been given to the morphological characters of the species inhabiting these two host genera to permit of accurate determination of the various collections, and the conclusions were consequently misleading.

The studies of Dr. F. D. Kern and the writer[51] a few years since showed that the American aecia previously referred to this species really belonged elsewhere, and that no genuine aecia of the species had been collected in America in all probability. After completing the cultures here recorded some of the resulting material was sent to Professor Fraser, and with a knowledge of the appearance and habit of the aecia thus acquired he was able to go into the field and gather excellent specimens.[52] The reason they have not been taken before by American collectors is doubtless due to their somewhat inconspicuous and evanescant character.

SUCCESSFUL CULTURES REPORTED NOW FOR THE FIRST TIME:— The following species have never before been cultivated, in America or elsewhere, so far as the writer knows.

1. PUCCINIA CRANDALLII Pam. & Hume on *Festuca confinis* Vasey collected by Mr. E. Bethel, at Boulder, Colo., on March 19, 1910, was sown April 21, on *Symphoricarpos racemosus, Grindelia squarrosa, Hydrophyllum capitatum* and *Arnica* sp., with infection only on the first. The pycnia began to appear May 9, and aecia May 26, neither in abundance. This was an unsuspected result, and immediately upon detecting evidence of infection, a second sowing was made upon another plant of *Symphoricarpos racemosus* (May 10), which yielded more pronounced results. Pycnia began to appear in ten days (May 20), and aecia in eleven days more (May 31), both well formed and numerous.

A second lot of this rust, on *Festuca confinis* Vasey, was received from Professor A. O. Garrett, collected in City Creek Canyon, Salt Lake City, Utah, April 10, 1910, and sown on the same date as the previous sowing, May 10. Pycnia began to show May 20, and aecia June 6.

[51] Bull. Torrey Club 33: 429, 430. 1906.
[52] Cf. Mycologia 3: 69. 1911.

The results of these cultures agree perfectly with *Aecidium abundans* Peck which was first collected in Colorado, on *Symphoricarpos oreophilus,* the exact locality not being stated.

2. PUCCINIA QUADRIPORULA Arth., on *Carex Goodenovii* J. Gay, collected by the writer in the type locality at Isle au Haut, Me., was sown April 18 on *Iris versicolor, Boehmeria cylindrica,* and *Rudbeckia laciniata,* with no infection. Again April 26 it was sown on *Myrica cerifera, Lysimachia terrestris, Macrocalyx Nyctelea, Polemonium reptans, Apocynum cannabinum, Senecio lugens,* and *Aster paniculatus,* with infection only on the last, pycnia being first noticed May 13, and aecia appearing May 17, neither very abundant.

Field observations seemed to connect this rust with aecia on *Iris,* but previous attempts at cultures had given no certain evidence.[53] The results this year appear beyond question. No other *Carex* rust grew in the vicinity of the spot where the collection was made. The material used shows only the characteristic rust. The aecia obtained, however, are both in gross and minute characters indistinguishable from those of *P. Caricis-Asteris* Arth. These facts make the status of the species enigmatical. The marked diagnostic characters of *P. quadriporula* and *P. Caricis-Asteris* lie in the urediniospore. The former has a somewhat larger urediniospore, more usually globose, and with four, often three, equatorial pores, while the latter has a smaller urediniospore, more ellipsoid or elongated, and with two superequatorial pores. The pore characters are markedly dissimilar, and without intergradations.

Another collection with the spore characters of *P. quadriporula,* made by Professor W. P. Fraser, at Pictou, Nova Scotia, on *Carex brunnescens* (Pers.) Poir., was sown April 11, and again May 6, on *Iris versicolor, Urtica gracilis,* and *Ribes floridum,* with no infection.

3. PUCCINIA LITHOSPERMI E. & K., on *Evolvulus pilosus* Nutt., collected at Amarillo, Texas, by W. H. Long, was sown April 15, on the same species of host, and produced a scanty infection. Pycnia were not observed until May 2; aecia began to appear

[53] See Mycol. 1: 230. 1909.

May 6. The result shows that the species is eugyrinious and autoecious.

4. UROMYCES ACUMINATUS Arth., on *Spartina Michauxiana* A. S. Hitch. (usually listed as *S. cynosuroides*), collected by Dr. J. F. Brenckle at Kulm, N. D., was sown April 28 on *Steironema ciliatum* and *Polemonium reptans,* with abundant infection on the latter only, showing pycnia May 9, and aecia May 14.

A similar collection made by Mr. E. Bethel in the foothills of Colorado was sown May 12, on *Steironema ciliatum, Hydrophyllum capitatum, Phlox divaricata,* and *Polemonium reptans,* with very abundant infection only on the last, showing pycnia May 20, and aecia May 26. Another collection made at Fair Oaks, Ind., by Messrs. F. D. Kern and T. Billings, was sown one week later on the same hosts, but gave no infection, doubtless due to the lateness of the season.

These results bear out the field observations of Professor Guy West Wilson, as stated in the report for 1909.[54] The aecial stage is known in literature as *Aecidium Polemonii* Peck, and occurs on species of *Phlox* as well as on *Polemonium.*

5. COLEOSPORIUM VERNONIAE B. & C. Freshly gathered leaves of *Pinus taeda* L., bearing *Peridermium carneum* Bosc, gathered by Mr. O. F. Burger at Gainesville, Fla., May 18, 1910, were suspended on May 21, over potted plants of *Veronia crinita, Elephantopus carolinianus* and *Lacinaria scariosa.* Contrary to expectation uredinia began to show in abundance June 6 on the *Veronia* only. Numerous telia began to mature by August 16.

6. MELAMPSORA ALBERTENSIS Arth., on *Populus tremuloides* Michx., was sent by Mr. E. Bethel on three different dates, collected at different places in the foothills of Colorado, and all showing telia in resting condition. The first collection was sown April 20, on *Larix laricina* and *Pseudotsuga mucronata,* giving infection on the latter only, showing an abundance of pycnia May 2, and an equal abundance of aecia May 9. The second collection (from Plainview, Colo.), was also sown April 20, on the same two hosts, but without results. Later on, May 18, duplicate sowings were made. This time the *Larix* remained free, and the *Pseudotsuga* after a long interval was found to have been infected,

[54] See Mycol. 2: 222. 1910.

the pycnia and aecia being first noticed June 6. The third collection was sown May 19, on the same hosts, with infection only on *Pseudotsuga,* numerous pycnia showing May 31, and equally numerous aecia June 9.

The aecia on *Pseudotsuga* were first brought to my attention by Professor E. W. D. Holway, who sent a collection from Beaver River valley, B. C., in 1907. This collection was described by the writer, and named *Caeoma occidentale.*[55] The following year Mr. E. Bethel sent collections from Eldorado Springs, Colo., and in 1909 he sent other collections from Eldorado Springs, and also from Tolland and Golden. From observations made at these places Mr. Bethel suggested that the connection between the *Caeoma* on *Pseudotsuga* and the *Melampsora* on *Populus* was unquestionable. The aecial stage is doubtless rather common throughout the range, but it is so inconspicuous and evanescent that it has been very little collected.

SUMMARY

The following is a complete list of the successful cultures made during the year 1910. It is divided into two series, species that have previously been grown in cultures and reported by the writer or other investigators, and species whose culture is now reported for the first time.

A. Species Previously Reported

1. *Puccinia Grossulariae* (Schum.) Lagerh.—Teliospores from *Carex tenuis* Rudge and from *C. pallescens* L., sown on *Ribes Cynosbati* L.

2. *Puccinia Peckii* (DeT.) Kellerm.—Teliospores from *Carex lanuginosa* Michx., sown on *Onagra biennis* (L.) Scop., and from *C. trichocarpa* Muhl., sown on *O. biennis* (L.) Scop. and *Meriolix serrulata* (Nutt.) Walp.

3. *Puccinia Caricis-Solidaginis* Arth.—Teliospores from *Carex scoparia* Schk., sown on *Euthamia graminifolia* (L.) Nutt.

4. *Puccinia Caricis-Asteris* Arth.—Teliospores from *Carex festiva* Dewey, sown on *Aster adscendens* Lindl.

[55] Bull. Torrey Club 34: 591. 1907.

5. *Puccinia Opizii* Bubák.—Teliospores from *Carex siccata* Dewey, sown on *Lactuca canadensis* L. and *L. sativa* L.

6. *Puccinia universalis* Arth.—Teliospores from *Carex stenophylla* Wahl., sown on *Artemisia dracunculoides* Pursh.

7. *Puccinia Caricis* (Schum.) Schröt.—Teliospores from *Carex aristata* R. Br. and *C. stricta* Lam., sown on *Urtica gracilis* Ait.

8. *Puccinia angustata* Peck.—Teliospores from *Scirpus atrovirens* Muhl., sown on *Lycopus americanus* Muhl.

9. *Puccinia Andropogonis* Schw.—Teliospores from *Andropogon virginicus* L., sown on *Pentstemon hirsutus* (L.) Willd. and from *A. scoparius* Michx., sown on *Pentstemon alpinus* Torr.

10. *Puccinia pustulata* (Curt.) Arth.—Teliospores from *Andropogon furcatus* Muhl., sown on *Comandra umbellata* (L.) Nutt.

11. *Puccinia amphigena* Diet.—Teliospores from *Calamovilfa longifolia* (Hook.) Hack., sown on *Smilax hispida* Muhl.

12. *Puccinia Muhlenbergiae* Arth. & Holw.—Teliospores from *Muhlenbergia racemosa* (Michx.) B. S. P., sown on *Callirrhoe involucrata* (T. & G.) A. Gray.

13. *Puccinia Rhamni* (Pers.) Wettst.—Teliospores from *Calamagrostis canadensis* (Michx.) Beauv., sown on *Rhamnus alnifolia* L'Her.

14. *Puccinia poculiformis* (Jacq.) Wettst.—Teliospores from *Agropyron tenerum* Vasey, *Sitanion longifolium* J. G. Sm., and *Agrostis alba* L., sown on *Berberis vulgaris* L.

15. *Puccinia subnitens* Diet.—Teliospores from *Distichlis spicata* (L.) Greene, sown on *Chenopodium album* L.

16. *Puccinia Jamesiana* (Peck) Arth.—Teliospores from *Atheropogon curtipendulus* (Michx.) Fourn., sown on *Asclepias syriaca* L.

17. *Puccinia Seymouriana* Arth.—Teliospores from *Spartina Michauxiana* A. S. Hitchc., sown on *Cephalanthus occidentalis* L.

18. *Puccinia Stipae* Arth.—Teliospores from *Stipa spartea* Trin., sown on *Aster ericoides* L., *A. Novae-Angliae* L., *A. multiflorus* Ait., and *Solidago canadensis* L., from *Stipa* sp., sown on *Aster Novae-Angliae* L., and *Grindelia squarrosa* (Pursh) Dunal, and from *Koeleria cristata* (L.) Pers., sown on *Senecio lugens* A. Gray.

19. *Puccinia argentata* (Schultz) Wint.—Aeciospores from *Adoxa Moschatellina* L., sown on *Impatiens aurea* Muhl.

20. *Puccinia Absinthii* DC.—Teliospores from *Artemisia* sp., sown on *A. dracunculoides* Pursh.

21. *Uromyces perigynius* Halst.—Teliospores from *Carex intumescens* Rudge, sown on *Aster paniculatus* Lam., and from *C. deflexa* Hornem., sown on *Solidago rugosa* Mill., and *Aster ericoides* L.

22. *Uromyces Junci* (Desm.) Tul.—Teliospores from *Juncus Balticus* Willd., sown on *Carduus Flodmanii* Rydb.

23. *Uromyces Astragali* Sacc.—Urediniospores from *Aragallus Lamberti* (Pursh) Greene, and from *Astragalus sulphurescens* Rydb., sown on *Astragalus carolinianus* L.

24. *Uromyces Medicaginis* Pass.—Urediniospores from *Medicago sativa* L., sown on same host.

25. *Gymnosporangium Juniperi-virginianae* Schw.—Teliospores from *Juniperus virginiana* L., sown on *Malus Malus* (L.) Britt.

26. *Gymnosporangium clavipes* C. & P.—Teliospores from *Juniperus sibirica* Burgsd., sown on *Amelanchier erecta* Blanch., and *Crataegus tomentosa* L., and aeciospores from *Amelanchier erecta* Blanch., sown on *Juniperus sibirica* Burgsd.

27. *Gymnosporangium clavariaeforme* (Jacq.) DC.—Teliospores from *Juniperus sibirica* Burgsd., sown on *Amelanchier erecta* Blanch., and *Crataegus punctata* Jacq.

28. *Gymnosporangium nidus-avis* Thaxt.—Teliospores from *Juniperus virginiana* L., sown on *Cydonia vulgaris* Pers., and *Amelanchier vulgaris* Moench.

29. *Gymnosporangium cornutum* (Pers.) Arth.—Teliospores from *Juniperus sibirica* Burgsd., sown on *Sorbus americana* Marsh.

30. *Gymnosporangium Davisii* Kern.—Teliospores from *Juniperus sibirica* Burgsd., sown on *Aronia arbutifolia* (L.) Medic., and *A. nigra* (Willd.) Britt.

31. *Gymnosporangium Betheli* Kern.—Teliospores from *Juniperus scopulorum* Sarg., sown on *Crataegus cerronis* A. Nels.

32. *Gymnosporangium Nelsoni* Arth.—Teliospores from *Juniperus virginiana* L., sown on *Amelanchier erecta* Blanch.

33. *Cronartium Quercus* (Brond.) Schröt.—Aeciospores from *Pinus virginiana* Mill., sown on *Quercus rubra* L.

34. *Melampsoropsis abietina* (A. & S.) Arth.—Teliospores from *Ledum groenlandicum* Oeder, sown on *Picea Mariana* (Mill.) B. S. P.

B. Species Reported Now for the First Time

1. *Puccinia Crandallii* Pam. & Hume.—Teliospores from *Festuca confinis* Vasey, sown on *Symphoricarpos racemosus* Michx.

2. *Puccinia quadriporula* Arth.—Teliospores from *Carex Goodenovii* J. Gay, sown on *Aster paniculatus* Lam.

3. *Puccinia Lithospermi* E. & K.—Teliospores from *Evolvulus pilosus* Nutt., sown on same species of host.

4. *Uromyces acuminatus* Arth.—Teliospores from *Spartina Michauxiana* A. S. Hitch., sown on *Polemonium reptans* L.

5. *Coleosporium Vernoniae* B. & C.—Aeciospores from *Pinus taeda* L., sown on *Vernonia crinita* Raf.

6. *Melampsora albertensis* Arth.—Teliospores from *Populus tremuloides* Michx., sown on *Pseudotsuga mucronata* (Raf.) Sudw.

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